ANALYSIS OF STRUCTURES UNDER SEISMIC LOADING USING FAST NONLINEAR ANALYSIS

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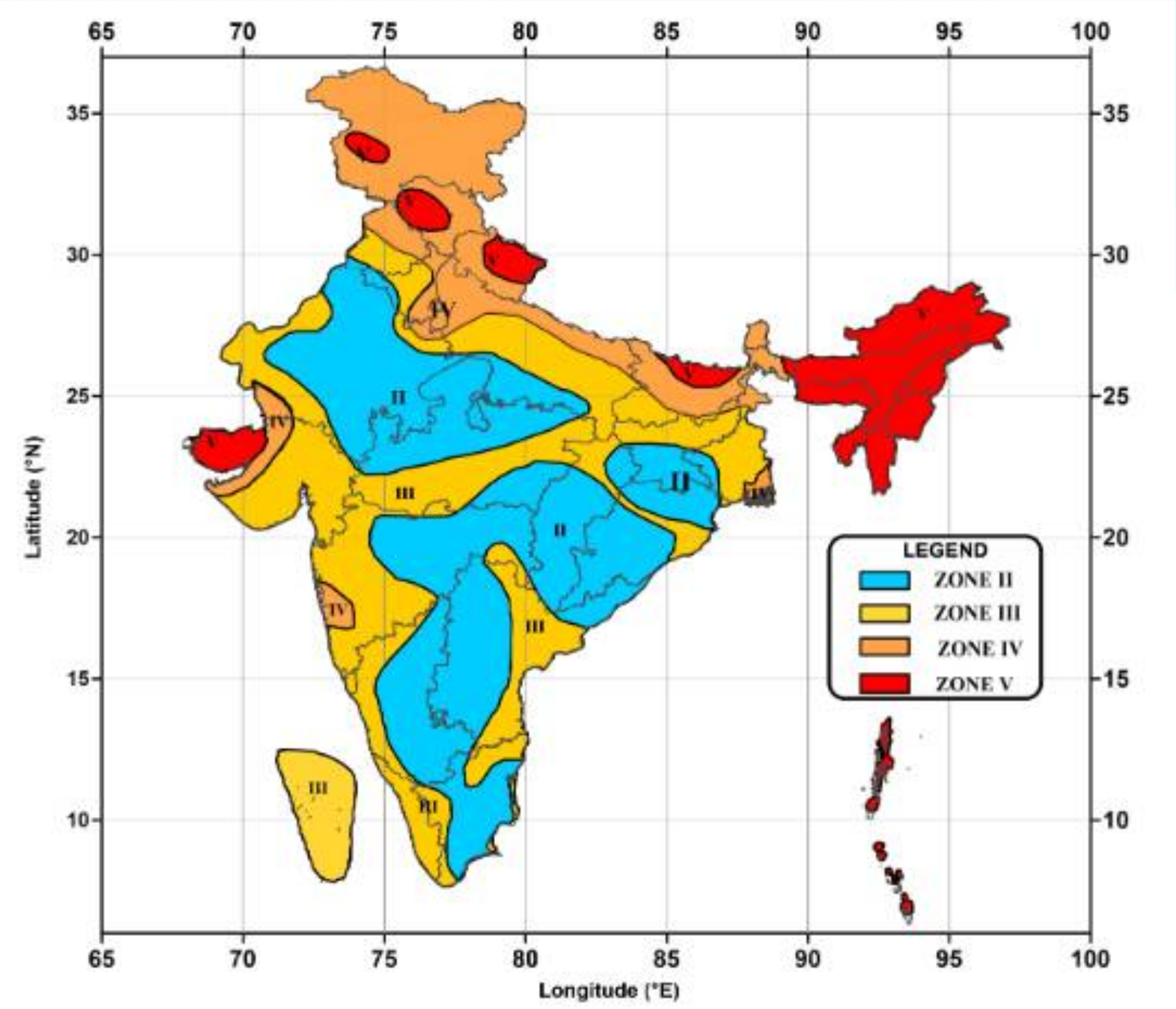
Motivation to Make This Project

We are currently residing in Assam, which is a seismic zone 5 on the India zone map. This place is prone to frequent earthquakes. Hence the design of buildings under seismic loads becomes necessary. Structures under seismic loading are evaluated on the basis of their relative displacement and the amount of acceleration they experience. Here we are going to analyze two types of damping devices and their effect on the structures under seismic loading.



What is Fast Nonlinear Analysis?

Fast Nonlinear Analysis (FNA) is a modal analysis method useful for the static or dynamic evaluation of linear or nonlinear structural systems. Because of its computationally efficient formulation, FNA is well-suited for time-history analysis and often recommended over direct-integration applications. During dynamic-nonlinear FNA application, analytical models should:

- Be primarily linear-elastic.
- Have a limited number of predefined nonlinear members.
- Lump nonlinear behavior within link objects.

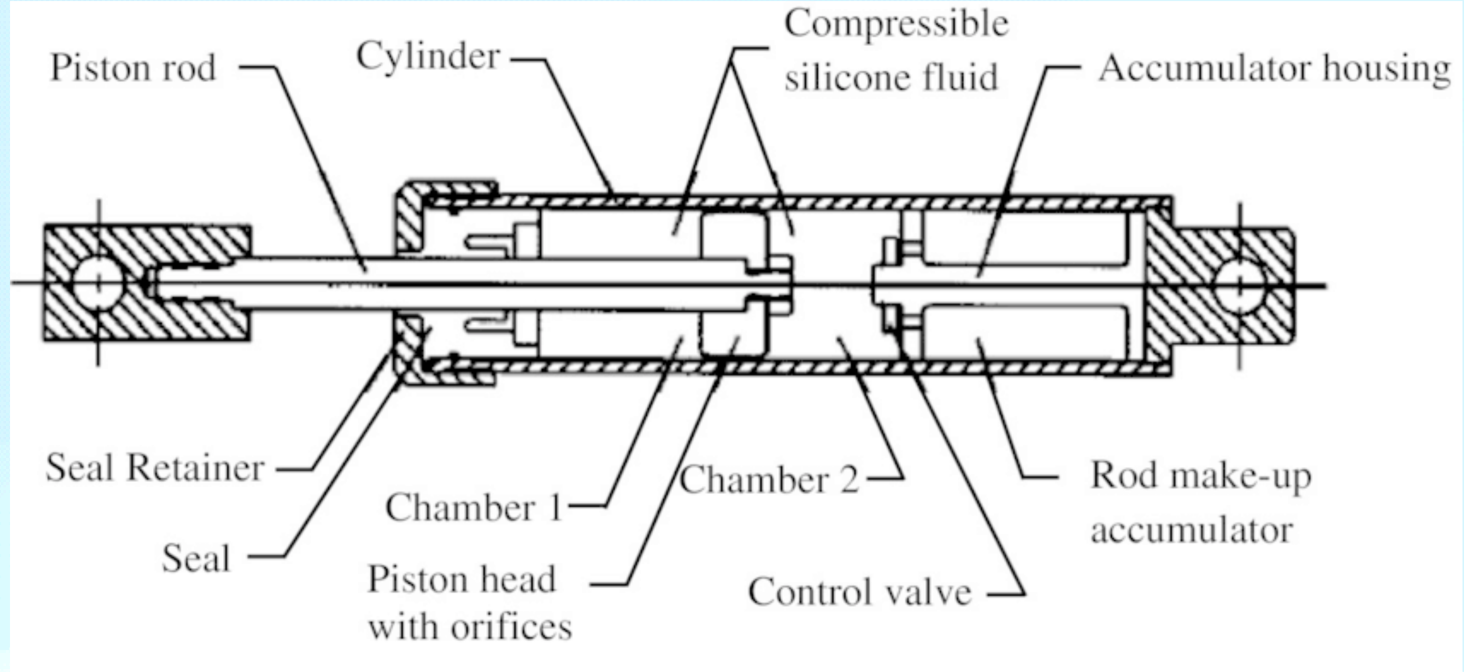
In addition to nonlinear material force-deformation relationships, these link objects may simulate concentrated damping devices, isolators, and other energy-dissipating technologies. If fuse mechanisms are not integral to the design intention, an initial elastic analysis may reveal locations where inelasticity is likely to occur. However, it is always best to predefine inelastic mechanisms such that their design may provide for sufficient ductility while elastic systems are ensured sufficient strength.

IMPLEMENTATION

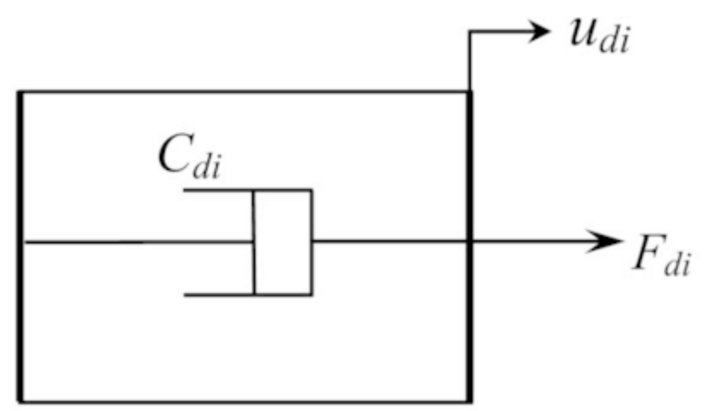
- We use SAP2000 to conduct time history analysis of structures under seismic loading using fast nonlinear analysis.
- For easy understanding, we use a 2D three storey frame using a different system that protects the structure against severe input energies from earthquakes and harmful deflection.
- The mechanical devices used in the question are Dampers and triple pendulum isolators

IMPLEMENTATION (Cont..)

Seismic Dampers permit the structure to resist severe input energy and reduce harmful deflections, forces and accelerations to structures and occupants. There are several types of seismic dampers namely viscous damper, friction damper, yielding damper, magnetic damper, and tuned mass damper.



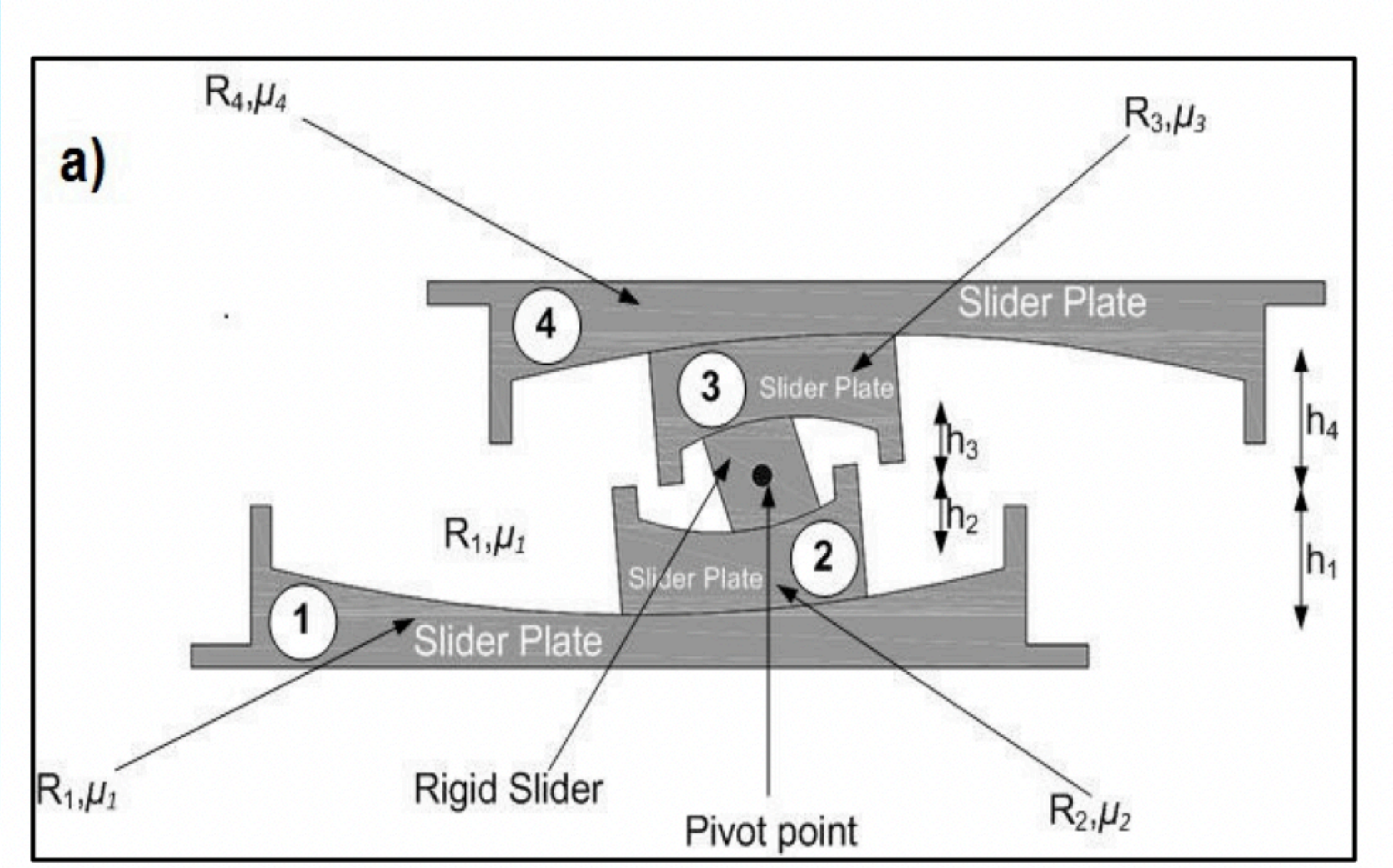
(a) Schematic diagram of fluid viscous damper (Symans and Constantinou, 1998)



(b) Mathematical model of fluid viscous damper

IMPLEMENTATION (Cont..)

The Triple Pendulum isolator offers better seismic performance, lower isolator costs, and lower construction costs as compared to other seismic isolation technology. The properties of each of the isolator's three pendulums are chosen to become sequentially active at different earthquake strengths. As the ground motions become stronger, the isolator displacements increase. At greater displacements, the effective pendulum length and the effective damping increase, resulting in lower seismic forces and isolator displacements.



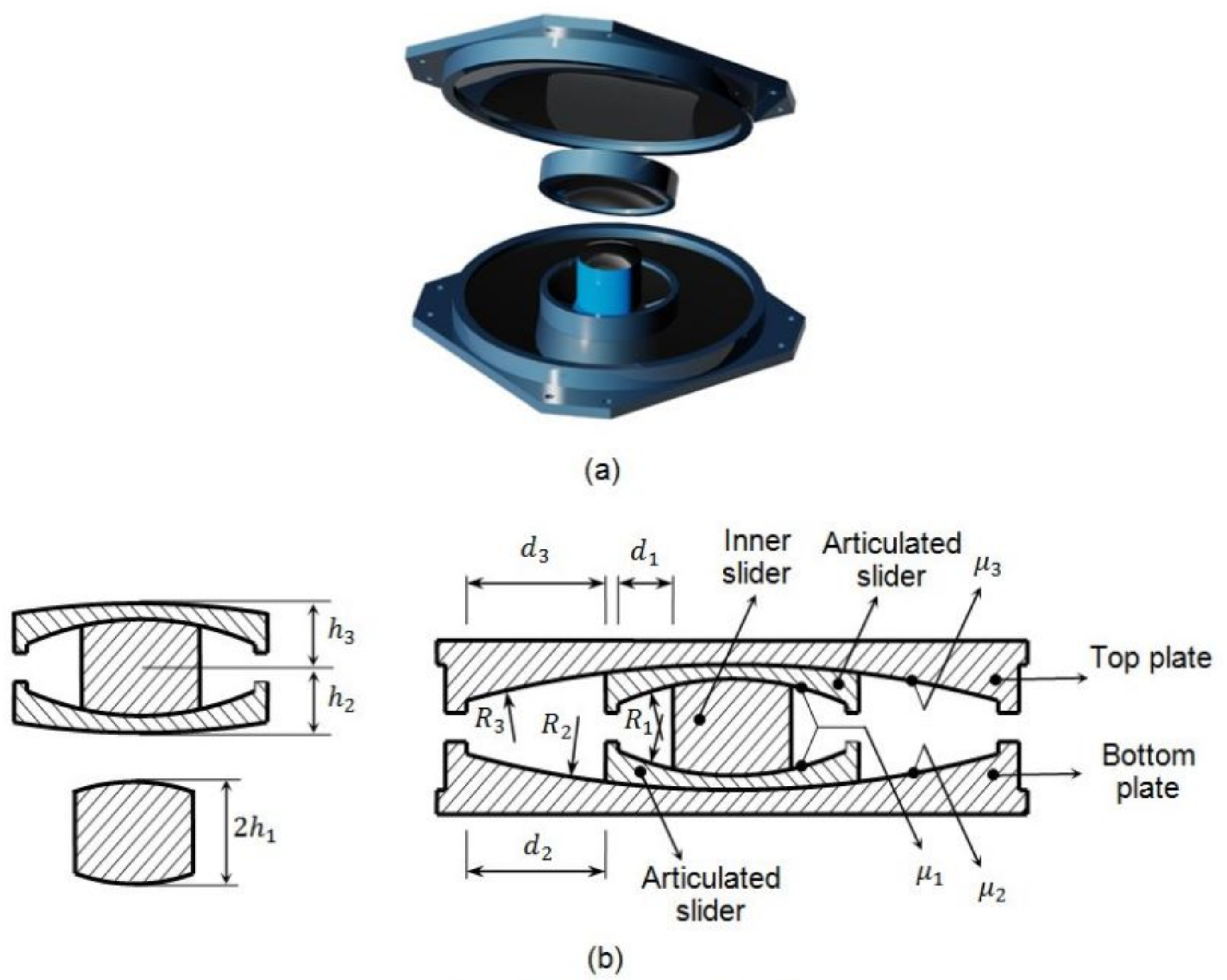
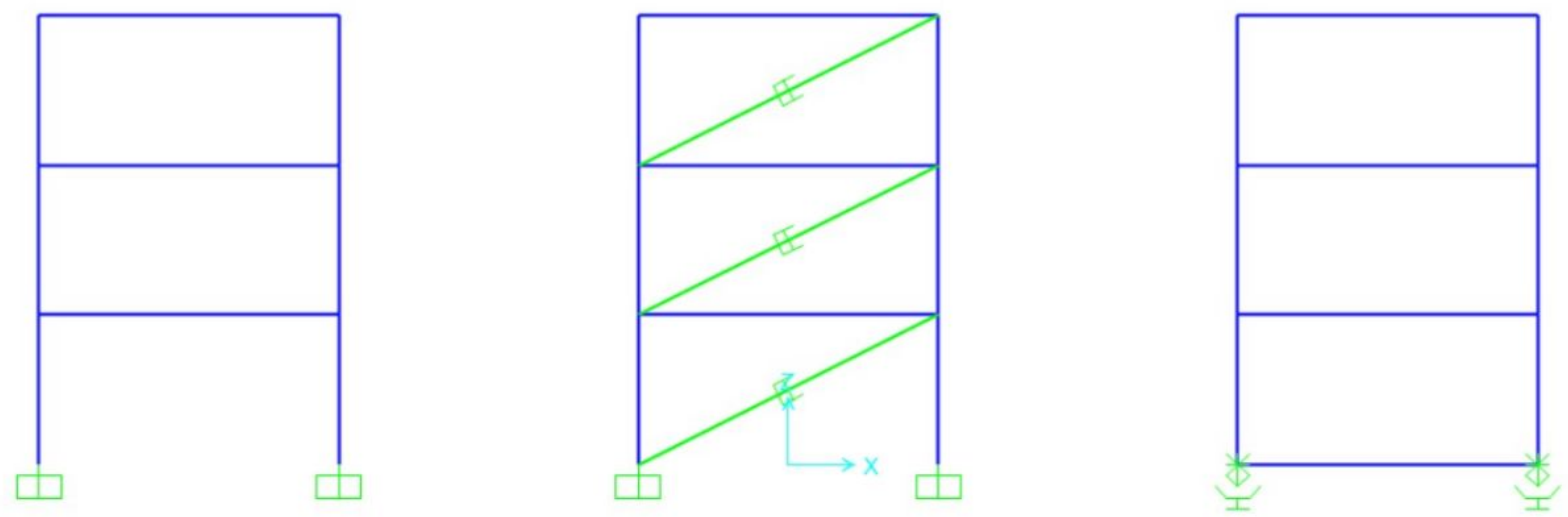


Figure 1: Triple friction pendulum bearing
(a) Three-dimensional view
(b) Section view and basic parameters

ASSEMBLY

The Assembly consists of three 2D rigid frames:

The first one is the reference frame with no device against seismic loading.
The second frame has viscous dampers, attached diagonally to opposite corners to prevent harmful deflections.
The third frame rests on triple pendulum friction isolators that use the weight of the structure to create friction against horizontal ground acceleration.

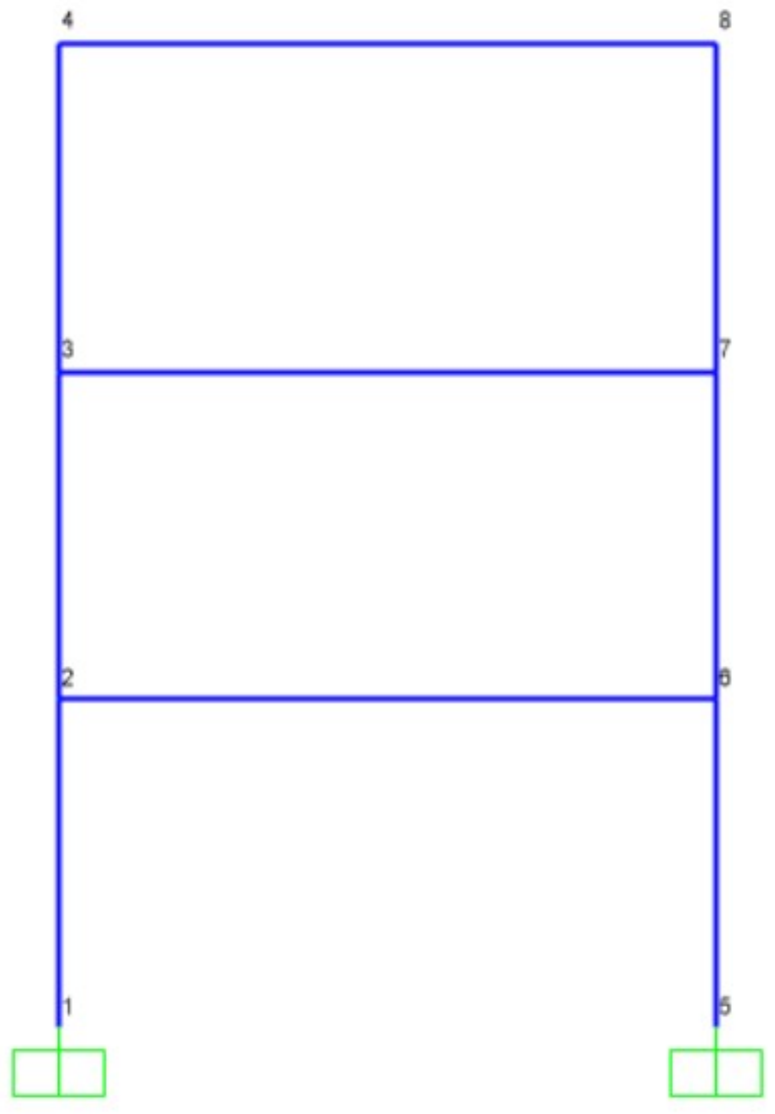


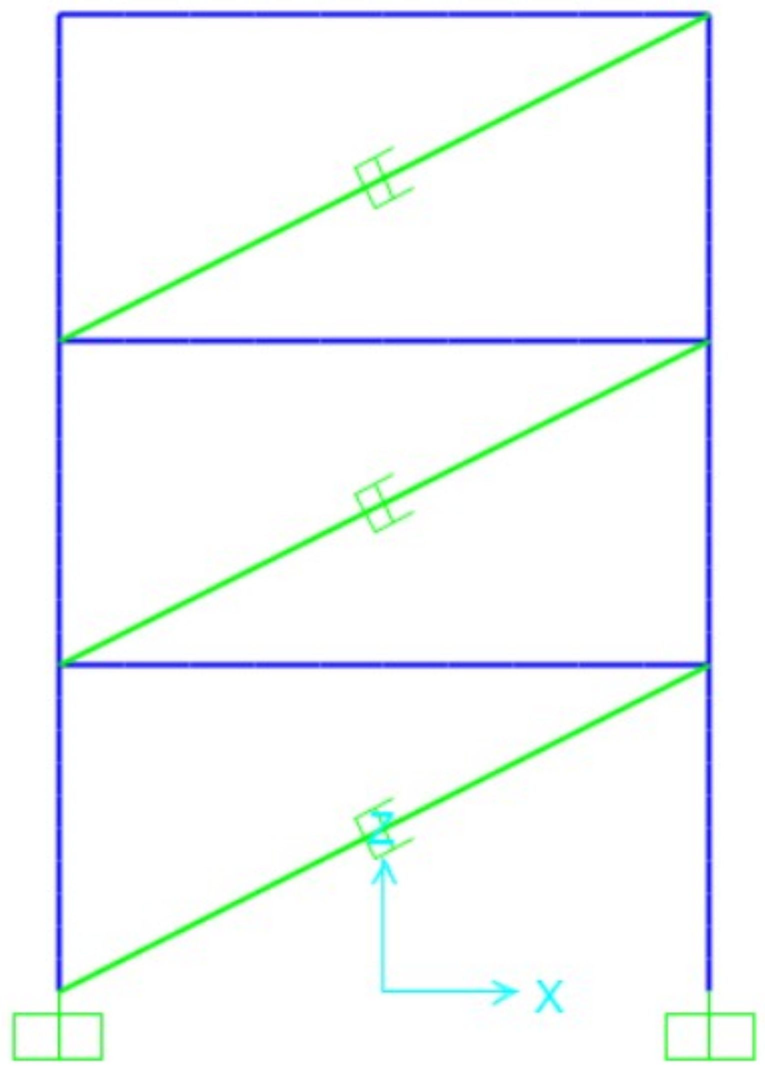
IMPLEMENTATION (Cont..)

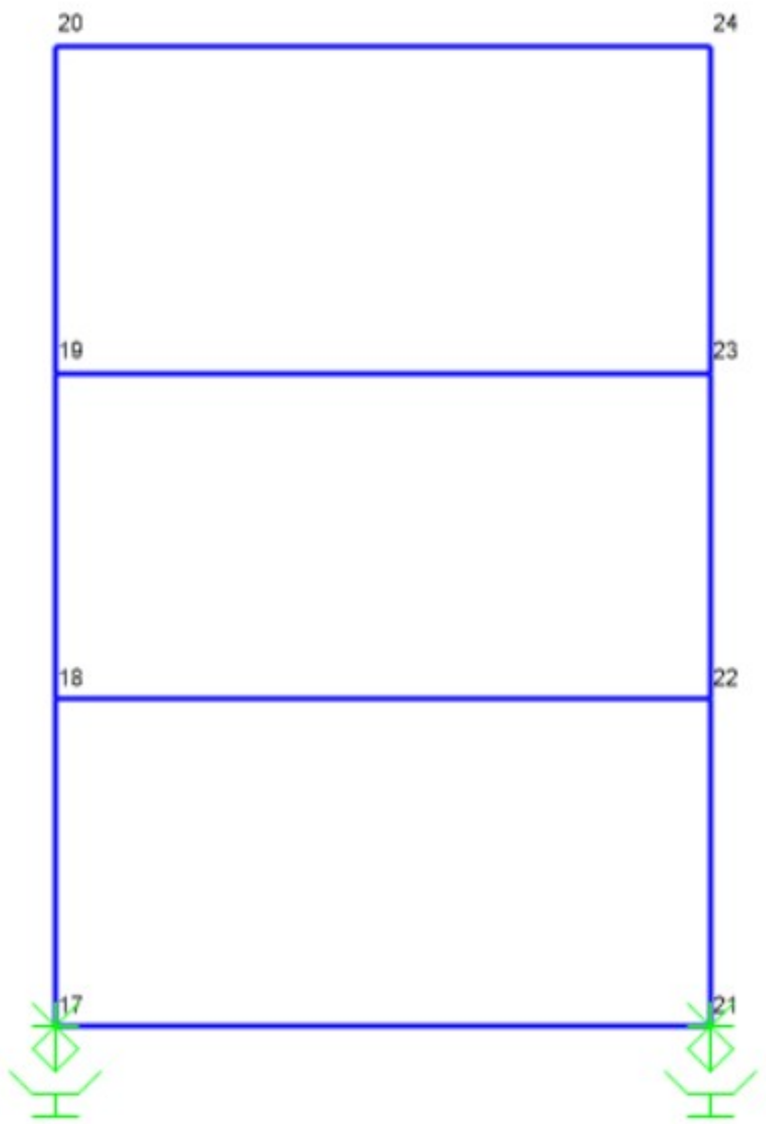
Reference Frame
- Fix Support
- 9 Member, 8 Joints
- Links Support- None

First Frame
- Fix Support
- 9 Member, 8 Joints
- Links Support- 3 Damper

Second Frame
- Restrained with release in X and Z direction
- 10 Member, 8 Joints
- Links Support- 2 triple pendulum Isolators



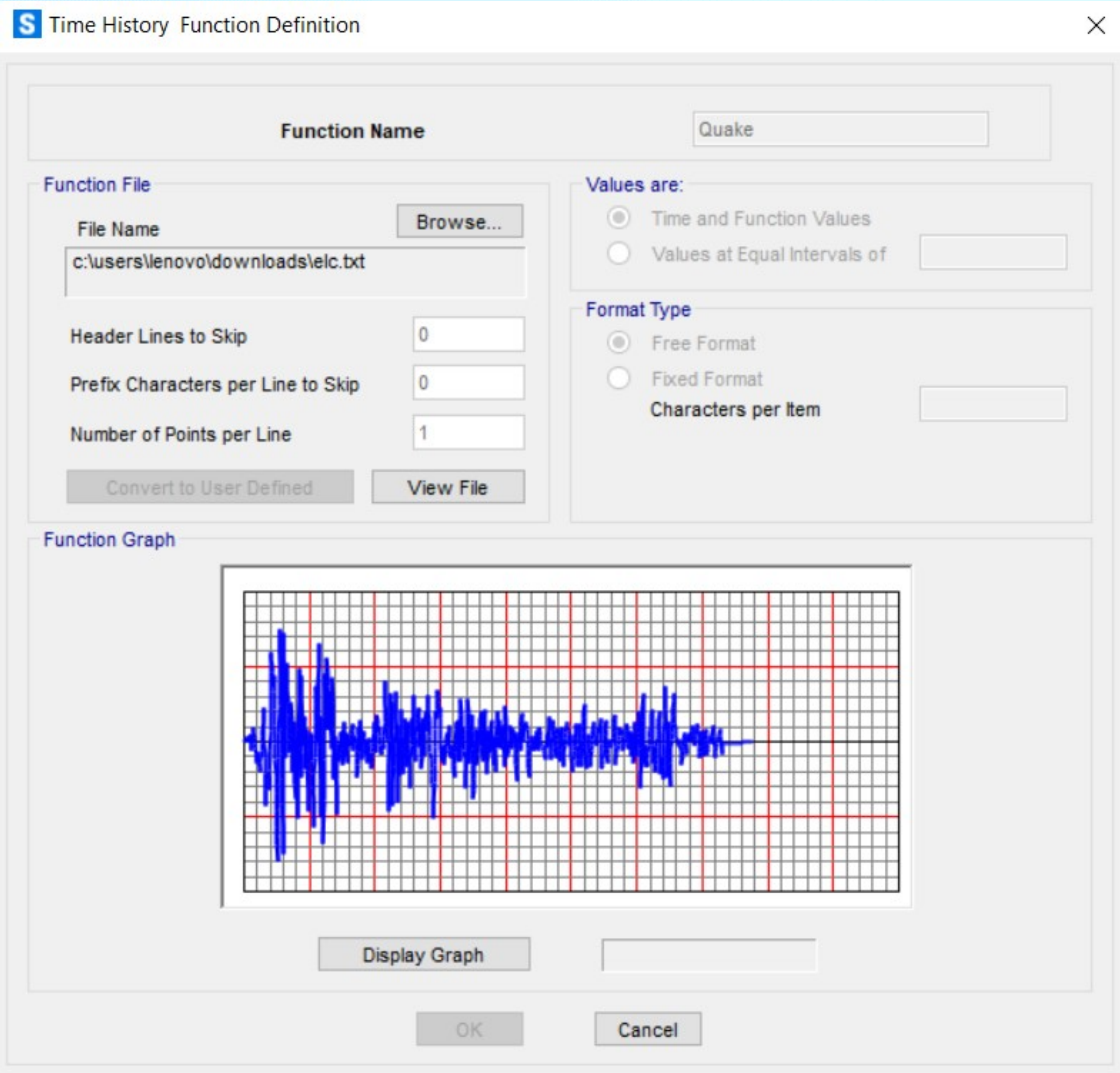




LOAD FUNCTION

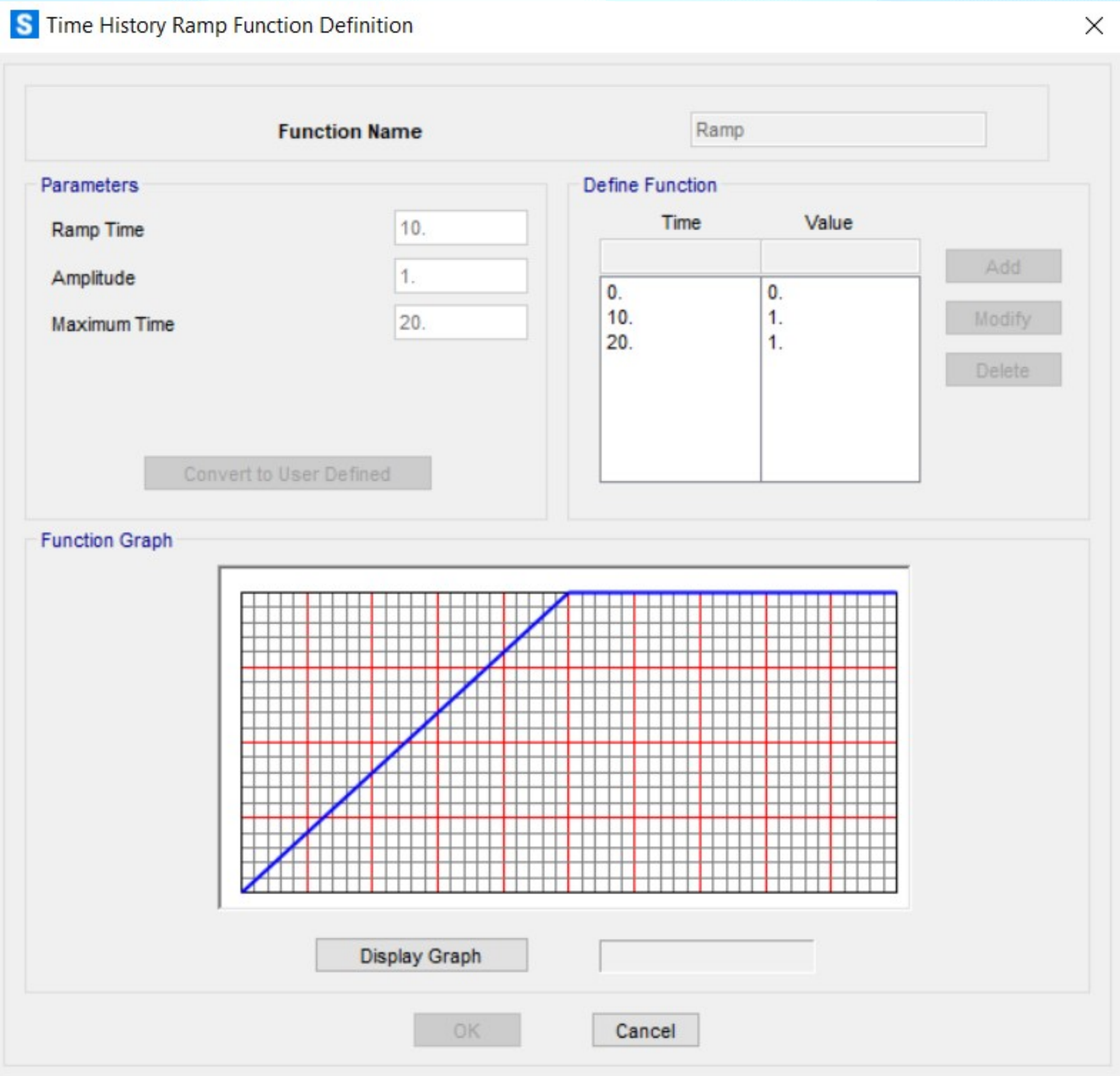
Seismic load Function

- Time vs Acceleration
- Earthquake El Centro may 18 1940
- Magnitude 7.1

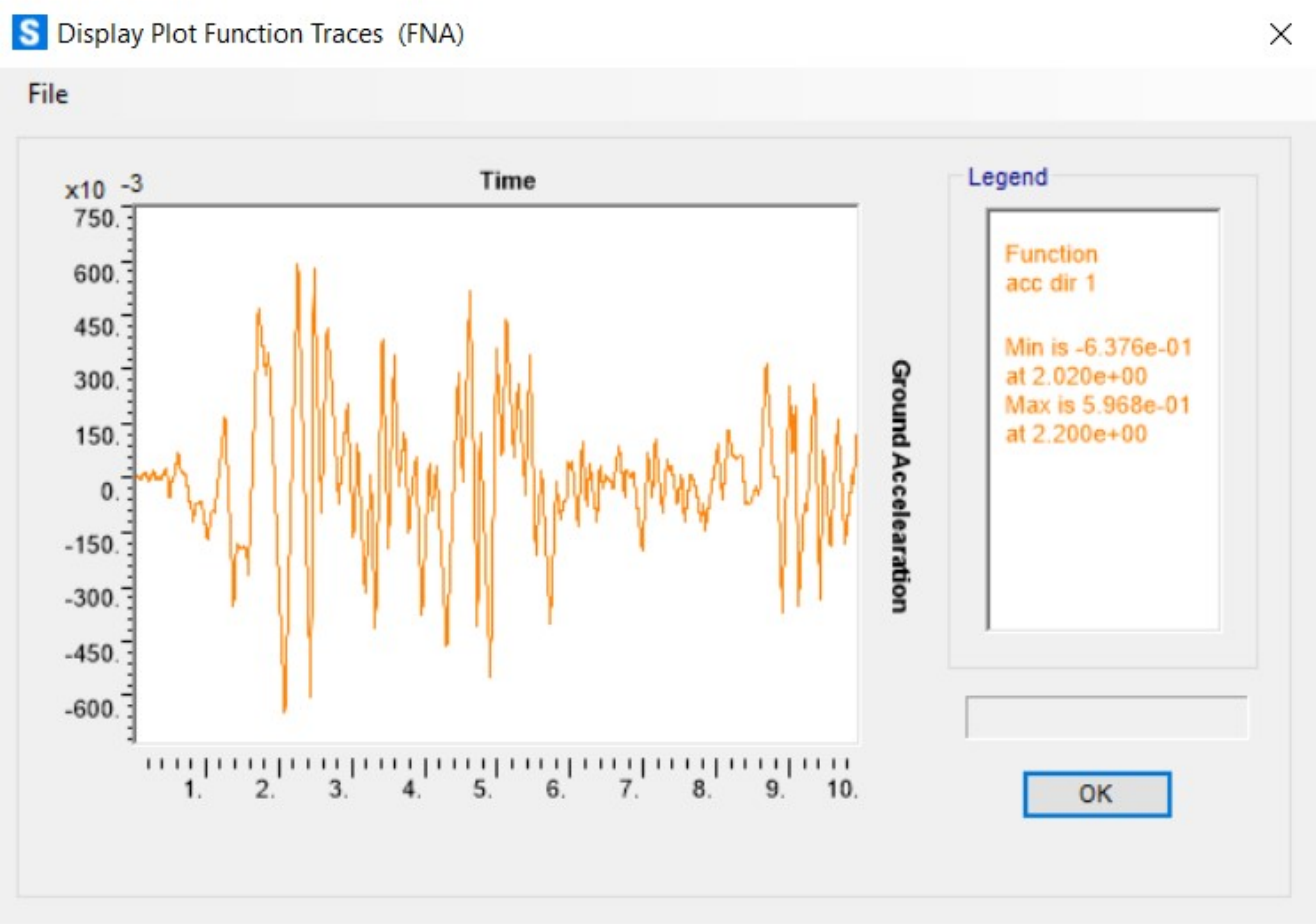


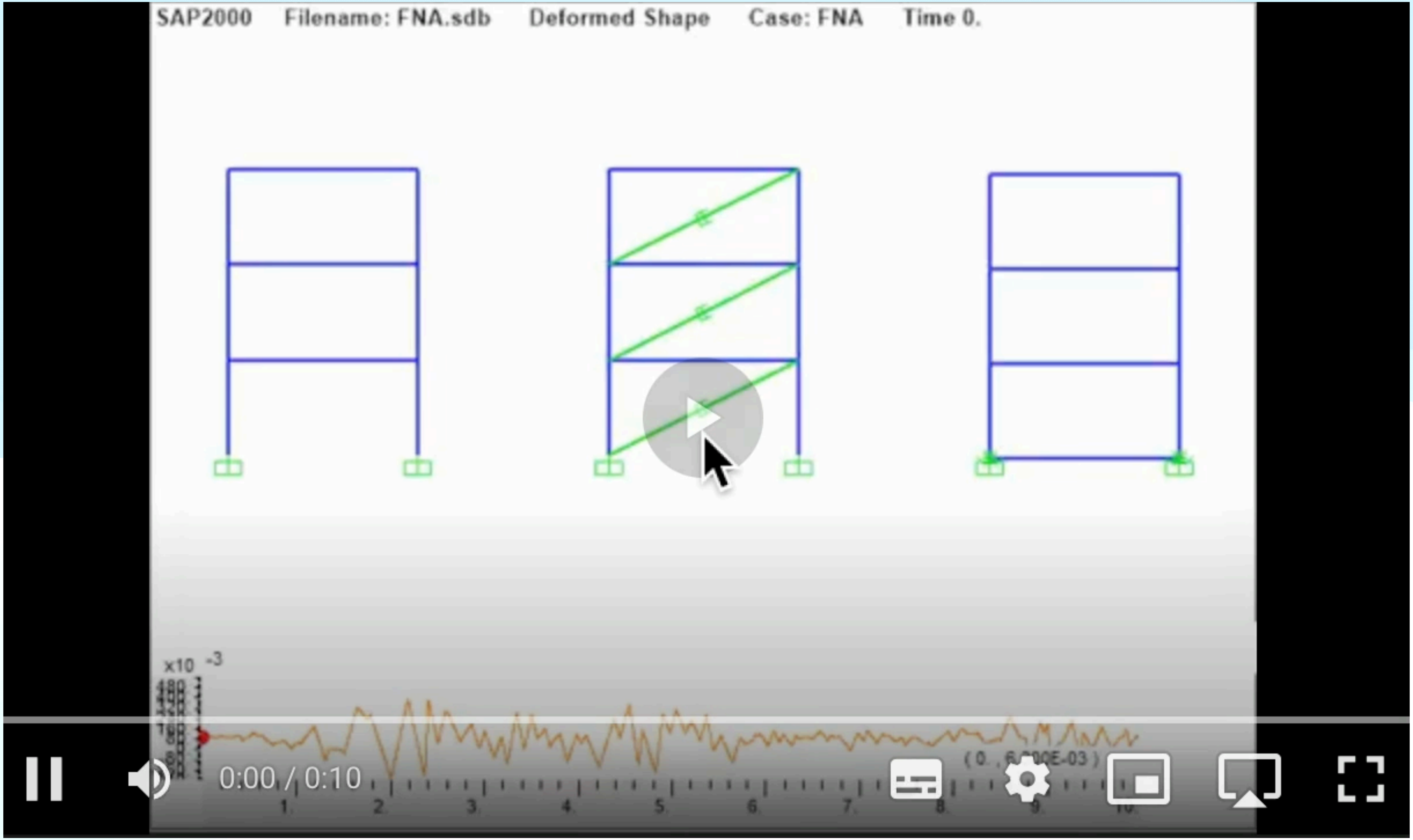
Ramp (Dead Load) Function

Slowly Increases Load over time till a constant dead load is achieved.



ANALYSIS RESULT

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Case: FNA
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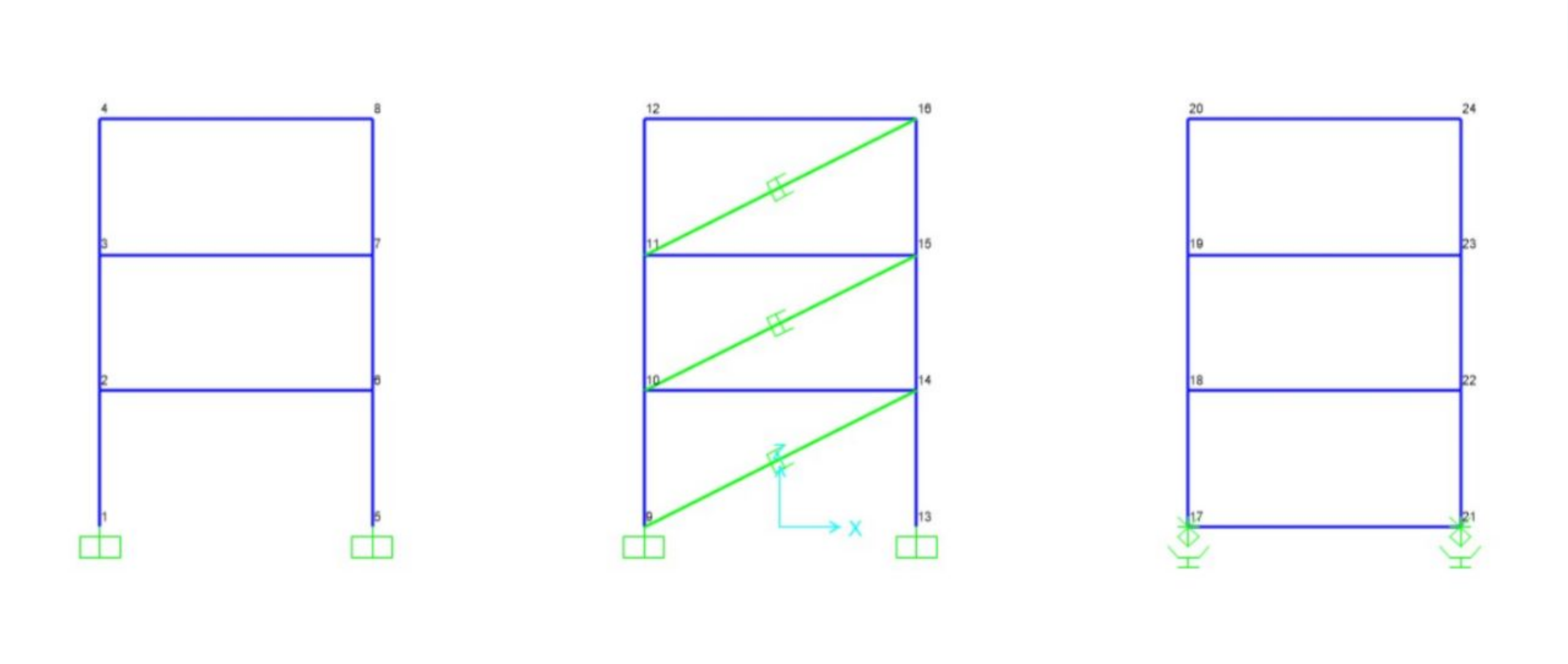
ANALYSING ACCELERATION AND DISPLACEMENT OF JOINTS 8, 16, AND 24



ACCELERATION AND DISPLACEMENT GRAPH